4. TRAIL DESIGN

This chapter provides specific design and implementation guidelines and standards to ensure that the Grand Junction Rail-with-Trail is constructed to a consistent set of the highest and best standards currently available in the United States. Ultimately, the Grand Junction Trail must be designed to meet both the operational needs of CSX and MIT as well as the safety of trail users. The challenge is to find ways of accommodating both types of uses without compromising safety or functionality.

Planning, design, and implementation standards in this document are derived from the following sources:

- Rails-with-Trails: Lessons Learned (August 2002)
- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets, 1994.
- AASHTO, Guide for the Development of Bicycle Facilities, 1999.
- U.S. Department of Transportation (USDOT), Federal Highway Administration (FHA), Manual of Uniform Traffic Control Devices (MUTCD), 2000.
- USDOT, FHWA, Selecting Roadway Design Treatments to Accommodate Bicycles, 1994.
- Florida Department of Transportation, State Bicycle/Pedestrian Program, Trail Intersection Design Guidelines, 1996.
- USDOT, FHWA, Conflicts on Multiple-Use Trails: Synthesis of the Literature and State of the Practice, 1994.
- Institute of Transportation Engineers (ITE), Design and Safety of Pedestrian Facilities, 1994.
- Rails-to-Trails Conservancy, Rails-with-Trails, Sharing Corridors for Transportation and Recreation, 1996.

The sources listed above provide details on many aspects of a rail trail, but a) may contain recommendations that conflict with each other; b) are not, in most cases, officially recognized "requirements"; and c) do not cover all conditions on most rail trails. All design guidelines must be supplemented by the professional judgments of the trail designers and engineers.

Recommended Width

The recommended width for paved multi-use trails is 14 feet in high-use urban areas, with 2-3 feet of lateral clearance and 8 feet of vertical clearance. In retrofit situations it can be difficult to achieve the desired 14', and 12' is commonly found. The minimum width from an operational standpoint is 8 feet in constrained situations and/or for short distances. Two-foot-wide unpaved shoulders with a compacted surface (often decomposed granite) should be located on each side of the paved surface to accommodate joggers and others who prefer a softer surface.

Signage and Striping

A yellow centerline stripe is standard for multi-use paths in Cambridge, especially when sections of the trail may incur heavy usage and/or where nighttime riding is expected.

Intersections and Crossings

In general, trail crossings should occur at established pedestrian crossings wherever possible, or at locations completely away from the influence of intersections. Mid-block crossings should address right-of-way for the motorist and trail user through use of Yield or Stop signs, or traffic signals that can be activated by trail users. Trail approaches at intersections should always have Stop or Yield signs to minimize conflicts with autos. Bike Crossing stencils may be placed in advance of trail crossings to alert motorists. Ramps should be designed to accommodate the range and number of users.

Specific trail crossing issues and treatments are discussed later in this document.

Design Speed

The minimum design speed for bike paths is 20 miles per hour, except on sections where there are long downgrades (steeper than 4%, and longer than 500 feet). Speed bumps or other surface irregularities should never be used to slow bicycles.

Horizontal Alignment

A 2% cross slope is recommended for drainage and accessibility, and should generally not be exceeded. The Grand Junction Rail-with-Trail runs along a linear corridor, with flat slopes. No sharp curves exist along the trail, except at trail entrance/exit points and at transitions at the north and south ends of the alignment.

Lateral Clearance on Horizontal Curves

Stopping sight distance on horizontal curves and lateral clearance can be calculated using the equations in the AASHTO Guide 2003. Sight distance is generally not expected to pose a problem on the Grand Junction Rail-with-Trail.

Gradients

Steep grades should be avoided on any multi-use trail, with 5% the recommended maximum gradient. Steeper grades can be tolerated for short distances (up to about 500 feet). The Grand Junction Rail-with-Trail corridor is nearly flat for most of the alignment.

Drainage

The 2% cross slope will resolve most drainage issues on a bike path, except along cut sections where uphill water must be collected in a ditch and directed to a catch basin, where the water can be directed under the trail in a drainage pipe of suitable dimensions.

Bollards / Barrier Posts

Posts at trail intersections and entrances may be necessary to keep vehicles from entering. Posts should be designed to be visible to bicyclists and others, especially at nighttime, with reflective materials and appropriate striping. Posts should be designed to be moveable by emergency vehicles.

Signing, Markings, and Traffic Control Devices

Bike path, bike lane, and bike route signing and markings should generally follow the guidelines as developed the Manual on Uniform Traffic Control Devices. This includes advisory, warning, directional, and informational signs for bicyclists, pedestrians, and motorists. The final striping, marking, and signing plan for Grand Junction Rail-with-Trail will be resolved in the full design phase of the trail, and should be reviewed and approved by a licensed traffic engineer or civil engineer. This will be most important at locations where there are poor sight lines from the trail to cross-traffic (either pedestrian or motor vehicle) such as at the Brain and Cognitive Sciences Building.

Rail-with-Trail Issues

This section provides guidance for specific railroad safety issues and other design issues related to rail-with-trails (RWTs). Much of the information in this section is based on the Rails-with-Trails: Lessons Learned Study. Again, engineering judgment and the requirements of the landholders must be applied.

Minimum Required Setback

Setback is measured from the nearest edge of the trail to the centerline of the nearest railroad track. No empirical data has been discovered indicating the precise setback that is recommended between a public trail and an active railroad. A review of 65 existing trails as part of the *Rails-with-Trails: Lessons Learned* report shows wide variance in the setback distance. Researchers attempted to determine if narrower setback distances have a direct correlation to safety problems. However, based on the almost non-existent record of claims, crashes, and other problems on these RWTs, they were unable to conclude a strong correlation between setback and safety. At an absolute minimum, the setback must keep trail users outside the "dynamic envelope" of the track, defined as "the clearance required for the train and its cargo overhang due to any combination of loading, lateral motion, or suspension failure."

Additionally, in corridors with regular use of maintenance equipment that operates outside the dynamic envelope, the setback distance should allow adequate clearance between the maintenance equipment and the trail.

The Federal Railroad Administration (FRA) already publishes minimum setback standards for fixed objects next to active railroad tracks, the distance between two active tracks, and adjacent walkways (for railroad switchmen). These published setbacks represent the legal minimum setbacks based on the physical size of the railroad cars, and are commonly employed along all railroads and at all public grade crossings. Most Public Utilities Commissions (PUC), which regulate railroad activities within states, also have specific minimum setbacks for any structures or improvements adjacent to railroads, including any sidewalk or trail that parallels active railroad tracks. According to the PUC standards, minimum distances from the centerline of an active railroad to the outside edge of a trail or bikeway is 8.5 feet on tangent and 9.5 feet on curved track.

The *Rails-with-Trails: Lessons Learned* Report outlines preferred setback distances, with encouragement toward as much setback distance as possible. It details circumstances under which a RWT can be set back a minimum of 10 feet, with greater width preferred. In the case of the Grand Junction corridor, the train speeds are slow (less than 20 mph) and frequencies are very low (four to six trains daily.) These meet the recommendations for a setback of less than 25 feet. Under Option 1 (with no BRT), the bulk of the corridor is able to have the RWT at a 20-foot setback, with a few tight spots where the trail setback would be 10 feet.

In all cases, reduced setbacks would be accompanied by increased safety measures such as high fencing.

Fencing and Barriers

A wide variety of physical barriers are used in RWT corridors. Of the 65 known RWT facilities operating in the United States today, 71 percent have some type of physical barrier between the trail and tracks. The types of barriers in use include fences, walls, vegetation, grade differences and ditches. MIT has indicated their preference for a fence between the trail and their property. It is assumed that CSX would prefer to see a fence separating the GJ RWT.

Fences are the most common type of physical barrier used in RWT corridors. A number of fencing types are available, ranging from simple low wood rail fences to tall, heavy-duty steel fences. Selection of a fencing type depends on the amount of trespassing anticipated along a given segment of the RWT, and the aesthetic qualities desired.

Need for Fencing

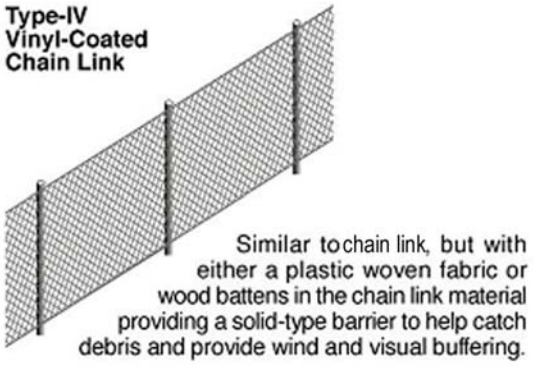
Some factors to consider when deciding on fencing necessity and styles include:

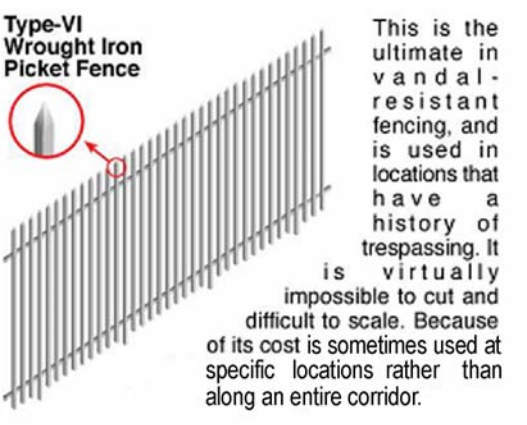
- Cost: Fencing and other barriers, depending on the type of materials used and the length, can be costly, so options should be considered carefully.
- Security: Fencing between the trail and adjacent land uses can protect the privacy and security of the property owners. While crime or vandalism have not proven to be a common problem along most multi-use trails, fencing is still considered a prudent feature. The type, height, and responsibility of the fencing is dependent on local policies.

- Fencing height: The height and design of a fence influences whether lateral movement will be inhibited. Few fences are successful at preventing people from continuing to cross at historic illegal crossing locations. Fencing that cannot be climbed will typically be cut or otherwise vandalized. Heavy-duty fencing such as wrought iron or other styles of fencing that are difficult to climb are often more expensive.
- Noise and dust: Although trains running along the corridor are low-speed and infrequent, they still generate noise, dust, and vibration, which may been seen as a nuisance to adjacent trail users. Methods of reducing this impact include the addition of vegetation or baffles to fencing barriers. This can increase the costs for a relatively low impact.

Fencing Type

Fencing style and material is a matter of local preference and railroad requirements. Some appropriate fencing types for the GJ RWT Trail would include the following:





According to the Metalco website, this fence style, Grigliato, is a very flexible and customizable system. It is suitable for commercial and industrial applications with medium to high security requirements. The system is based on a forge welded galvanized steel bar mesh.[7]

Figure 4-1. Fencing Types

[7] Information from the Metalco website (www.metalco.tv) viewed 01/28/06.

Recommendation

Fencing should be installed along the corridor. All fencing should be located a minimum of 10 feet from the nearest track centerline to allow for maintenance vehicles. Where the fence is located within 15 feet of the centerline of the nearest track, it should be designed to be removed as needed for rail maintenance work, unless adequate access can be provided on the opposite side of the tracks. All fencing should provide breaks or openings at least 5 feet wide every 500 feet to allow emergency access and escape.

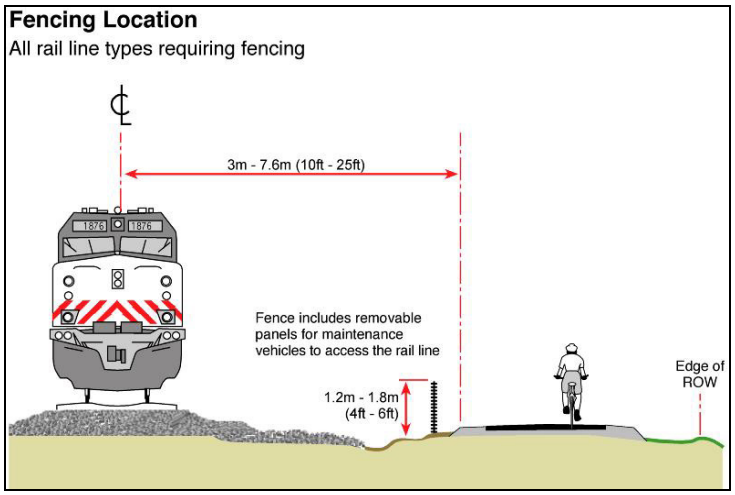


Figure 4-2. Fencing Location

With normal setback, fencing height should range between 36 inches and 48 inches, with 42 inches standard. On a roadway where the trail may be located closer than 15 feet from the edge of the trail to the centerline of the nearest track, the fence shall be at least 60 inches high with appropriate baffling material. Baffling material includes vegetation such as ivy or other vines, or a solid material such as wood.

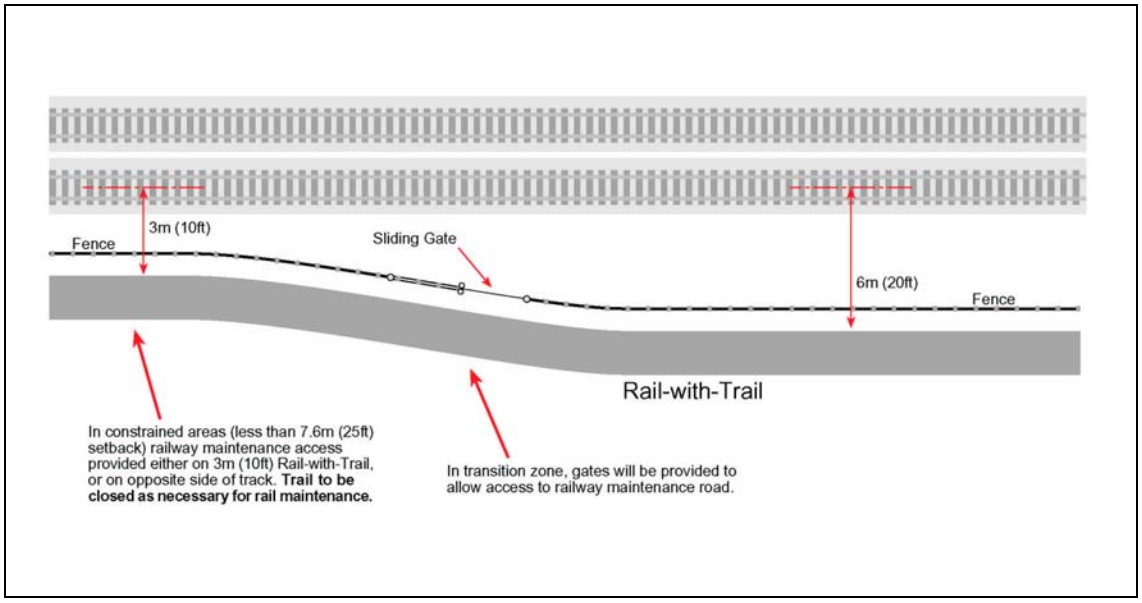


Figure 4-3. Railway Access

Regardless of fence type, railroad maintenance vehicles and/or emergency vehicles may need fence gates in certain areas to facilitate access to the track and/or trail. Fence design should be coordinated with railroad maintenance personnel, as well as representatives from utilities that extend along the corridor.

Vegetation

Whether natural or planted, vegetation can serve as both a visual and physical barrier between a track and a trail. The density and species of plants in a vegetative barrier determine how effective the barrier can be in deterring potential trespassers. A dense thicket can be, in some cases, just as effective as a fence (if not more so) in keeping trail users off the tracks. Even tall grasses can discourage trail users from venturing across to the tracks, although less effectively than trees and shrubs. Planted barriers typically take a few years before they become effective barriers. Separation between the trail and the track may need to be augmented with other temporary barriers until planted trees and hedges have sufficiently matured.

Trail-Roadway Crossings

The proposed Grand Junction Rail-with-Trail involves several at-grade roadway crossings, as well as three on-street track crossings. Each of these requires specific design treatments in order to ensure trail user safety, as well as compliance with railroad setback requirements.

Virtually all at-grade trail-roadway crossings are either unprotected, marked crossings, routed to an existing signal, or will require a new signal. Because of the proximity of the rail line, user movements must be considered.

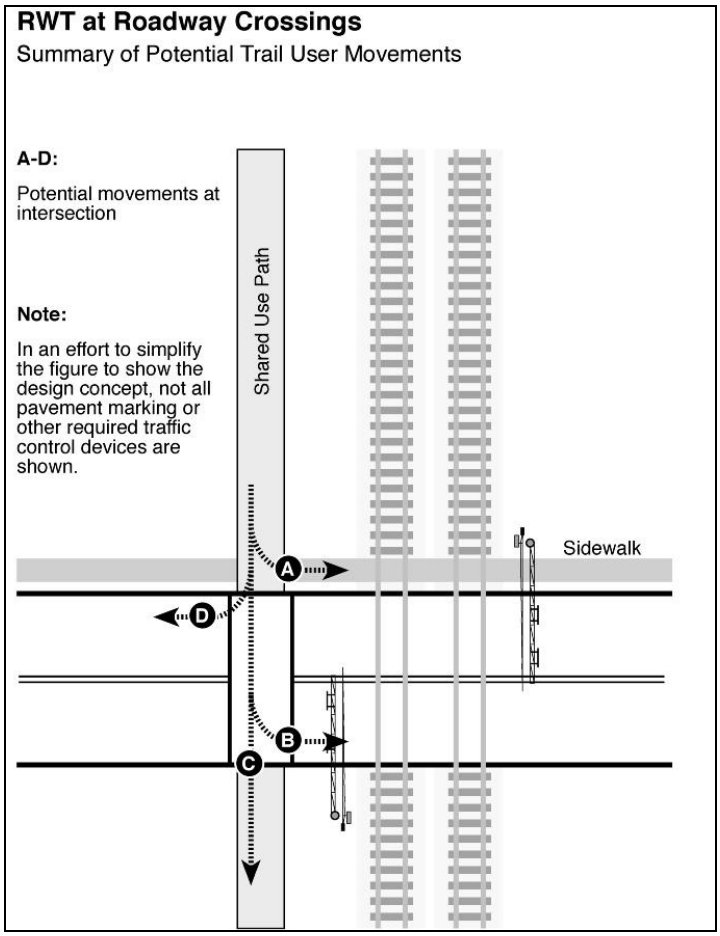


Figure 4-4. Trail-Roadway Crossings

The Grand Junction Rail-with-Trail crosses six at-grade roadways. Discussions of the individual crossings may be found in Chapter 3: Alternative Alignments. As noted earlier, the recommendations for design are:

Table 4-1. Roadway Crossing Design Recommendations

Roadway	Recommendation
Massachusetts Avenue	New signalized crossing coordinated with existing nearby signal
Main Street	Path users routed to existing signal
Broadway	Path users routed to existing signal
Binney Street	Uncontrolled crossing
Cambridge Street	Combine with existing Miller's River Apartment crossing

When considering a proposed off-street bike path and required at-grade crossings of roadways, it is important to remember two items: 1) trail users will be enjoying an auto-free experience and may enter into an intersection unexpectedly; and 2) motorists may not anticipate bicyclists riding out from a perpendicular trail into the roadway. However, in most cases, an at-grade trail can be properly designed to a reasonable degree of safety and meet existing traffic engineering standards.

Evaluation of bikeway crossings should involve an analysis of vehicular traffic patterns, as well as the behavior of trail users. This includes traffic speeds (85th percentile), street width, traffic volumes (average daily traffic and peak hour traffic), line of sight, and trail user profile (age distribution, destinations). A traffic safety study should be conducted as part of the actual civil engineering design of the proposed crossings to determine the most appropriate design features. This study would identify the most appropriate crossing options given available information, which must be verified and/or refined through the actual engineering and construction document stage.

Crossing Prototypes

Unprotected Crossings At "Little" Binney & Gore

Uncontrolled crossings (unsignalized, but with other traffic control devices) are recommended for streets with 85th percentile travel speeds below 45 mph and Average Daily Trips (ADTs) below 10,000 vehicles. All streets in Cambridge are signed at 30 mph or less; however, some of the streets have higher ADTs. An unprotected crossing consists of a crosswalk, signing, and often no other devices to slow or stop traffic. The approach to designing crossings at mid-block locations depends on an evaluation of vehicular traffic, line of sight, trail traffic, use patterns, road type and width, and other safety issues. See Figure 4-5 for general design.

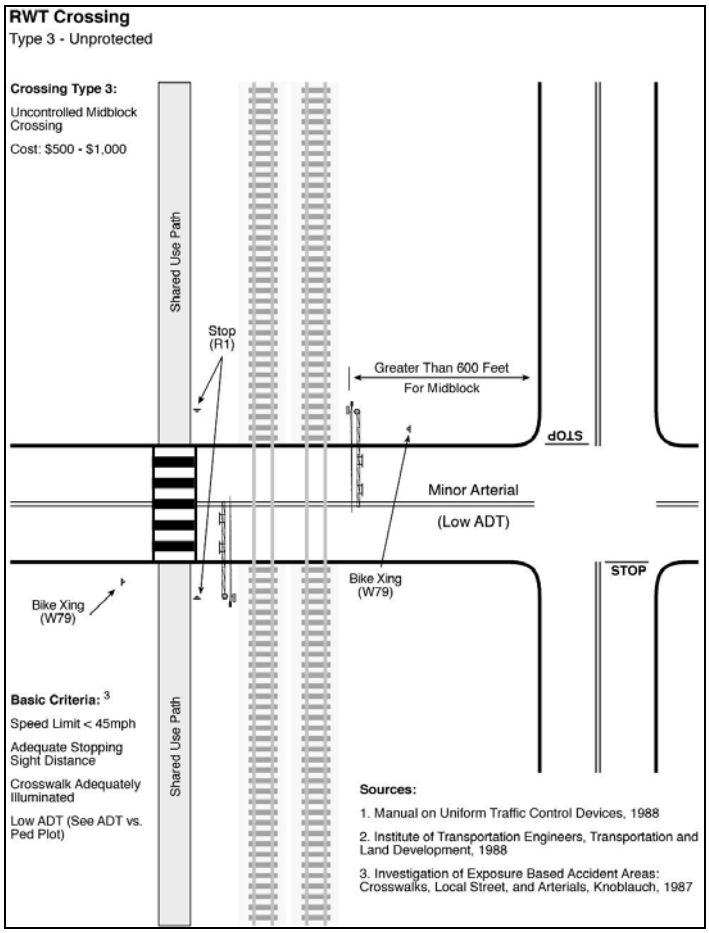


Figure 4-5. Type 3 RWT Crossing

Route to Existing Intersections (Main, Broadway, Miller's River, Manning Apts. on Cambridge)

Bike paths that either parallel a roadway or emerge closer than 200 feet from a protected intersection should be routed to that crossing in most cases. The reason is that motorists are not expecting to see pedestrians and bicyclists crossing so close to an intersection, traffic congestion may extend this distance, and the crossing may unnecessarily impact traffic capacity on a corridor.

Table 4-2 outlines the standard requirements for crossings at existing intersections.

Where the GJ RWT does not emerge at the existing intersection, carefully thought out physical design and directional signing will be required to keep bicyclists and others from crossing at the unmarked location. At the existing intersection crosswalk, all trail users will technically become pedestrians. Signs warning motorists of the presence of bicycles may be needed, as well as right turn on red prohibitions.

Table 4-2. Crossings at Existing Intersections

Standard Requirements	
Maximum Distance from Trail to Intersection:	Street Width 40 feet or less: 200 feet
	Street width over 40 feet: 350 feet
Length of barrier to prevent informal crossing	Street Width 40 feet or less: 50 feet
	Street Width over 40 feet: 100 feet
Intersection Improvements	Warning signs for motorists
	Right turn on red prohibitions
	Elimination of high speed and free right turns
	Adequate crossing time
	Pedestrian activated signals

One of the key problems with using existing intersections is that it requires bicyclists to transition from a separated two-way facility to pedestrian facilities such as sidewalks and crosswalks, normally reserved for pedestrians. Widening and striping the sidewalk (if possible) between the trail and intersection may help to alleviate some of these concerns.

Signalized Crossings (Massachusetts Ave.)

New or exclusive signalized crossings (Type 3) are identified for crossings more than 250 feet from an existing signalized intersection and where 85th percentile travel speeds are 45 mph and above and/or ADTs 10,000 vehicles. Signals require the input of local traffic engineers, who review potential impacts on traffic progression, capacity, and safety. On corridors with timed signals, a new trail crossing may need to be coordinated with adjacent signals to maximize efficiency. Trail signals are normally activated by push buttons, but also may be triggered by motion detectors. The maximum delay for activation of the signal should be 60 seconds, with minimum crossing times determined by the width of the street and trail volumes. The signals may rest on flashing yellow or green for motorists when not activated, and should be supplemented by standard advance warning signs. Typical costs for a signalized crossing range from $75,000 to $150,000. Along the Grand Junction corridor, one additional signalized crossing would be installed at Massachusetts Avenue that will be coordinated with existing nearby signals based on these issues.

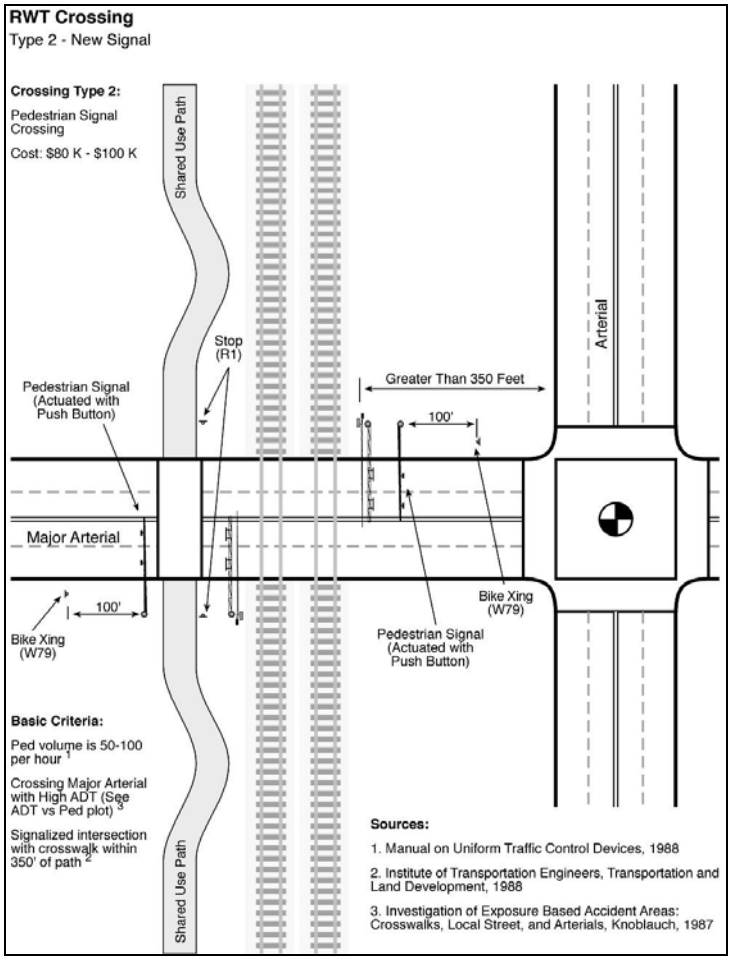


Figure 4-6. Type 2 RWT Crossing

Railroad Crossings

The preferred GJ RWT alignment would include no new at-grade crossings of the railroad tracks, although improvements might be necessary at the current crossings. New pedestrian railroad crossing flashers are typically not required for sidewalk crossings at legal crossings because they are redundant with adjacent vehicle crossing warning equipment. This type of crossing would be appropriate for Main Street where the trail crosses the Grand Junction tracks and is diverted to the signal at Main Street and Galileo Street.

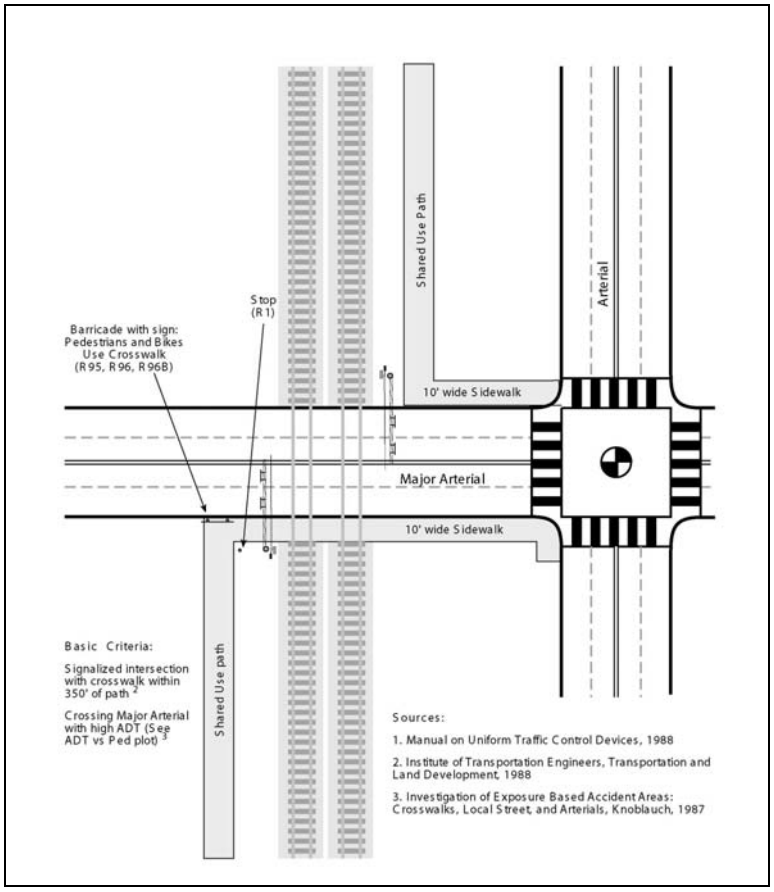


Figure 4-7. Railroad Crossings

Other Trail Design Issues

Utilities and Lighting

Surface and sub-surface utilities are located within the railroad right of way, impacting the location and construction of the GJ RWT. Utilities include active and abandoned railroad communications cable, signal and communication boxes, fiber optic cable, water and sewer lines, and telephone lines. The GJ RWT will be designed to avoid having to move most active surface utilities, although utility poles no longer in use may be removed. The trail may be located directly over existing sub-surface utilities assuming a) adequate depth exists between the trail surface and utility to prevent damage; and b) agreements can be reached with the utility owner regarding access for repairs and impact to the trail.

Trail lighting can be artistic, utilitarian, or both.

Installation of lighting along the Grand Junction Trail should be included to provide trail users extended hours of use, particularly during the winter months, and as an additional method in deterring crime along the corridor.

In general, lighting is recommended at trail access points and mid points between blocks to provide sufficient lighting for trail users and to help facilitate security surveillance of the trail from police vehicles. Light cut-offs are recommended to minimize unwanted light onto private property.

Signing and Marking

The GJ RWT should be designed with the recommended signing and marking in the Manual of Uniform Traffic Control Devices (MUTCD) in mind. It should also be identified by a consistent, unique logo or design that will help guide people to and on the trail. In general, all signs should be located three to four feet from the edge of the paved surface, have a minimum vertical clearance of 8.5 feet when located above the trail surface and be a minimum of four feet above the trail surface when located on the side of the trail. All signs should be oriented so as not to confuse motorists. The designs (though not the size) of signs and markings should generally be the same as used for motor vehicles.

Entrance Features

Major entrances to the GJ RWT may contain a variety of support facilities and other items, depending on available resources and local support. Typical entrance features would include:

- Trailhead. The trail will draw substantial numbers of users during peak times. A trailhead could provide amenities such as drinking fountains, telephones, bike lockers, or information boards. Public art and/or entrance signs may be placed at the entrance. Entrance signs should include all the relevant trail regulations. Signs may be placed at the entrances or at appropriate locations along the trail that provide brief descriptions of historic events or natural features.

- Bollards. A single 48-inch wood or metal bollard (post) should be placed on the centerline of the trail at all entrances to prevent motor vehicles from entering the trail. The bollard should be designed with high reflective surfaces and be brightly painted. The bollard should be locked to a ground plate and be easily removed by emergency vehicle operators.

Landscaping

Landscaping along the GJ RWT should provide intermittent visual relief. Shrubbery should be located to provide windows of visibility for safety and seasonal color. Alongside fencing, planting should be located to minimize maintenance and protect trail users from wind and noise. Intersections should be planted with groundcover and low shrubs in order to provide the required visibility for train engineers, roadway travelers (motorists, pedestrians, bicyclists), and trail users. Columnar trees should be planted that will not interfere with trains but will provide shade for trail users. Attention should be taken to plant groves to prevent "staccato" or "strobing" effects of rhythmic planting trees and shadows.

Choices of plants should respect the sharing of the right-of-way with the rail and introduce seasonal color and shade. Groundcovers and shrubs should be water-efficient. Trees selected should be both deciduous and evergreen, and located at the edges of the rail corridor, also providing a windscreen in places.

Irrigation should be predominantly drip, and plant materials should be capable of self-sustainability within two to three years. Irrigation should be minimal after establishment of plant material.

Public Art

In keeping with Cambridge's 1% for Art Program, any city-funded and built public project must include public art. The Cambridge Arts Council works with the project manager to select artists and incorporate appropriate art into the project.

Accesibility

Because Grand Junction is quite flat, meeting goals for accessibility should be straightforward. There are additional guidance documents for specific items that may require recommendations, such as FHWA's "Designing Sidewalks and Trails for Access, Part II, Best Practices Design Guide, 2001."